Soybeans

Economic Analyses Relating to Processing

by Martin S. Simon – Agricultural Economic Statistician

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PREFACE

The Production and Marketing Administration, the Farm Credit Administration, and the Bureau of Agricultural Economics are making a joint study of economic and technological factors associated with the processing of soybeans. The study is being conducted under the Agricultural Marketing Act of 1946 (RMA, Title II). This research seeks to learn what the economic effects upon farmers and soybean processors would be if new processing methods and equipment were adopted.

As one part of this study, the Bureau of Agricultural Economics is investigating the relationship between the price and the supply of soybean oil. This Bureau also is seeking to develop methods of estimating the effect of an increase in the yield of soybean oil upon prices of soybean products and upon total returns to growers and processors. These methods and the economic and statistical reasoning behind their development are presented here.

The Production and Marketing Administration is currently conducting research to determine what types of soybean-processing plants will be most feasible when new plants are to be built. The probable effects of such new plants upon prices and returns to growers and the industry will be discussed in detail in a publication to be issued by that agency when its phase of the study is completed. The PMA report will include use of equations developed in the present study.

The basic pattern of this report was derived from a similarly designed analysis of the cottonseed industry made by Sidney J. Armore. Mr. Armore's report was included as a second part of his study of the demand and price structure for all food fats and oils. Considerable use has been made in the present study of the results of his basic analysis of demand for major food fats and oils.

Credit is due Malcolm Clough and Sidney Gershben of the Bureau of Agricultural Economics, and Clifford H. Keirstead of the Production and Marketing Administration, for information and helpful suggestions. Special acknowledgment is made to Richard J. Foote of the Bureau of Agricultural Economics for assistance throughout the study. Most of the statistical computations were made by Floretta L. Downes.

SOYBEANS: ECONOMIC ANALYSES RELATING TO PROCESSING
With Emphasis on Analyses Designed to Measure Effects of Increased Yields of Soybean Oil on Prices and Total Returns

by

Martin S. Simon
Agricultural Economic Statistician
Bureau of Agricultural Economics

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SUMMARY

This report describes or develops certain analyses which can be used to measure the economic effects of adopting processing methods that increase yields of soybean oil. These analyses, summarized in two sets of equations, were developed particularly for use in determining probable effects of new processing methods upon prices and returns to farmers and to the soybean-processing industry.

Solvent extraction is the most efficient method in current use for recovering oil from soybeans. Based on averages for the 1947-49 and 1951 crop-years, it yielded about 20 percent more oil per bushel of soybeans crushed than the screw-press process and about 26 percent more than the hydraulic-press process. In 1949-50, solvents were used to process, for the first time, more soybeans than the screw-press method--56 percent of the total crush as compared to 41 percent. In 1951-52, almost three times more soybeans were processed by solvent equipment than by screw presses--74 percent of the total crush as compared to 25 percent. The remainder were crushed by hydraulic presses. These changes have had important economic consequences and hence warrant some study.

The first analysis considers the factors that affect prices of fats and oils, other than butter and lard, used in food products. In an analysis developed by Armore (1) 1/, three variables--per capita supply of fats and oils, other than butter and lard, used in food products, per capita supply of lard, and personal disposable income--explained 92 percent of the variation in prices of fats and oils, other than butter and lard, used in food products for 1922-42 and 1947-51. The average relationships between prices of these edible fats and oils and each independent factor, after allowing for the effects of other factors included in the analysis, were as follows: (1) A 1-percent change in the supply of edible fats and oils, other than butter and lard, was associated with a change of 1.6 percent in the opposite direction in price; (2) a 1-percent change in the supply of lard was associated with an opposite change of 1.1 percent in price; and (3) a 1-percent change in per capita disposable income was associated with a 1.4-percent change in price in the same direction.

A separate equation is used to determine the associated change in the price of soybean oil. On the average, a 1-percent change in prices of all fats and oils, other than butter and lard, used in food products was associated with a change of about 1 percent in the same direction in the price of soybean oil. After allowing for the influence of the general level of wholesale prices, 79 percent of the variation in prices of soybean oil for 1931-42 and 1947-51 was associated with changes in the total index.

The second analysis considers the effect of changes in the value of products obtained per bushel of soybeans processed on the season-average farm price of soybeans. Most of the annual variation in the season-average price received by farmers for soybeans is associated with changes in the total value

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1/ Figures in parentheses refer to Literature Cited, p. 35.

of oil and meal obtained per bushel of soybeans processed. For the 1931-40 and 1948-50 crop-years, the equation expressing the relationship between the particular variables used in the analysis indicates that the season-average price received by farmers tends to equal 75 percent of the combined value of the products obtained per bushel of soybeans processed, less 12 cents. The analysis is designed to show the normal relationship that prevailed in the past between these two factors and not to indicate the actual processing margin. It is recognized that this relationship might change with the adoption of new processing methods. Apparent changes in the relationship for the post-world War II years are discussed. As a result, certain modifications may be needed in its application.

The rationale behind the development of these equations is based on an analysis of the way in which the effects of an increase in the yield of soybean oil are likely to be transmitted. In brief, the following pattern would be expected.

An increase in the yield of soybean oil is likely to be accompanied by a decrease in the yield of soybean meal. Soybean oil competes directly with other edible fats and oils used as ingredients in the manufacture of edible fat and oil products, such as margarine and shortening. Soybean meal competes directly with other feed concentrates used in livestock rations, particularly several other protein supplements. A change in the yield of soybean oil would affect the total supply of competing edible fats and oils. Other factors associated with the food fats and oils economy may be affected also. A change in the yield of soybean meal would affect the total supply of protein supplements. In this way, the change would affect the feed-livestock economy.

Changes in the supply of edible fats and oils and of competing feed concentrates would cause changes in prices of these products, including those of soybean oil and meal. However, a given percentage change in the supply of soybean oil and soybean meal represents a smaller percentage change in the larger supply items. Consequently, the effect on prices of soybean oil and meal of changes in their supply would be less than if they were considered as commodities with no close substitutes. The changes in the price and yield of oil and meal would be reflected in the total value of products obtained per bushel of soybeans processed. As shown, the price received by farmers for soybeans is closely related to total product value. Although changes in the price of soybeans might affect the percentage of the crop sold and also production in subsequent crop years, these relationships, for reasons indicated, could not be determined statistically.

Apparently, the lower yield of meal that would be associated with greater oil recovery would not have much effect on the price of meal. Hence, statistical analysis of this relationship was not required. In the 1947-49 and 1951 crop-years, the solvent process yielded, on the average, about 4 percent less meal per bushel of soybeans crushed than the screw-press process and about 5 percent less than the hydraulic-press process. The meal obtained by solvent extraction ordinarily contains a higher percentage of protein and a lower percentage of oil than do meals produced by the mechanical processes.

PRODUCTS OBTAINED FROM PROCESSING SOYBEANS

The chief primary products of soybean processing are soybean oil and soybean oil meal. Soybean oil meal is the product obtained by grinding the residue (cake, chips, or flakes depending upon the processing method) that remains after most of the oil has been removed from the soybeans. In almost every year since 1936, more than 80 percent of the soybean crop, less quantities retained for use as seed, has been crushed for oil and meal. Minor quantities of soybeans are processed specifically for flour, and some oil is obtained as a byproduct. The oil or fat content of the flour depends upon the processing method employed. A negligible part of the soybean crop is ground whole for full-fat soy flour, which contains all of the oil originally found in the seed. 2/

Crude soybean oil is refined and used primarily in the production of food products such as vegetable shortening, margarine, and cooking and salad oils. A lesser quantity is consumed industrially in the manufacture of paints, varnishes, and other nonedible products.

Soybean meal is valuable chiefly because of its high protein content. Most of the soybean meal produced is used as a protein supplement in livestock feeding. The remainder is used chiefly for industrial purposes--in the manufacture of plywood glues, paper-coating adhesives, plastics, and several food products. Certain changes are usually made in the processing method when the meal is intended for use as food or in industrial products.

Production of soybean oil and soybean meal may be affected by many factors. Changes in acreage harvested for beans, in yield of soybeans per acre, in percentage of the crop sold to be crushed, in the oil content of the soybeans, or in the method of processing can cause changes in production of both oil and meal. The major objective of this report is to present statistical analyses that will make it possible to estimate the probable economic effects of adopting processing methods that will increase yields of oil. The general approach outlined can be used also in studying related problems concerned with the economic effects of a change in the yield of soybean oil brought about by such causes as the use of improved soybean varieties having a higher oil content or a change in regional patterns of soybean production. A more refined analysis of factors that affect the demand for soybean meal would be required before these methods could be used to investigate the economic effects of factors that cause changes in the supply of soybeans available for crushing. In the remainder of this section, factors that affect yields of soybean oil and meal, other than the processing method, are briefly considered.

Quantitatively, the yield of meal from processing a bushel of soybeans far exceeds the yield of oil. But, on the average, a pound of oil usually has sold for more than three times the price of a pound of meal. These ratios have been such that the value of the meal (yield times price) since 1931 ordinarily has

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2/ For a discussion of the steps involved in the production of soy flour, see Markley (10, v. 2, pp. 953-957).

been a little higher than that of the oil. In 1951, the meal from a bushel of soybeans was worth about twice as much as the oil. In most other oilseed crops, the meal usually represents a smaller percentage of total value than does the oil.

Table 1 shows the yields and values of oil and meal per bushel of soybeans processed and the percentage distribution of these values since 1931.

Factors that Affect Yields of Oil

Industry-average yields of oil per bushel of soybeans processed have trended upward from 7.4 pounds in 1924 to 10.0 pounds in 1951, an increase of about 35 percent. This upward trend resulted partly from improvements in processing techniques and partly from the development and cultivation of soybeans that contain greater quantities of oil. A decline in yields of oil during World War II reflected mainly a general overtaxing of soybean-processing capacity and the use of relatively inefficient and even obsolete equipment. From 1947 to 1951 the yield of oil ranged between 9.5 and 10.0 pounds (table 1).

The yield of crude oil is determined primarily by the oil content of the soybean seed. The oil content of seeds varies from about 14 to 24 percent on a moisture-free basis. Important commercial varieties usually contain from 18 to 22 percent oil. Oil content varies widely from year to year and from area to area. Climate and inherent characteristics of the different varieties apparently are major causes of variation. Oil content varies directly with the temperature during the growing season, which is considered the chief climatic influence. Climate and variety also affect various qualitative characteristics of the oil. 3/

Most soybeans in the United States are traded on the basis of official grades. Grades are determined by test weight per bushel, and by percentages of moisture, splits, damaged kernels, and foreign material. 4/ These factors are related to the quality as well as to the quantity of products obtained per bushel of soybeans processed.

Keirstead (9) has investigated statistically the relationship between oil content (expressed as a percentage of a 60-pound bushel of soybeans) and each of the soybean grade factors, for samples of soybeans grown in the major producing areas in the United States during the 1949 and 1950 crop-years. The nature of these relationships, as determined and discussed in that publication, are briefly indicated here. Oil content varies inversely with moisture content; the more moisture in a 60-pound bushel of soybeans, the smaller the quantity of oil obtained. As oil is lighter than the protein in soybeans, oil content varies inversely with test weight per bushel. Oil content also is affected by the

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3/ For a discussion of the variation in oil content by area and the influence of climate and variety on oil content and quality, see Pahigian (16), Keirstead (9), and Markley (10, v. 1, pp. 135-148).

4/ See Handbook of Official Grain Standards (23).

Table 1.- Soybean oil and meal: Yield, price per pound, and value per bushel of soybeans processed, averages 1931-45, annual 1946-51

Year beginning October	Yield 1/		Price 3/		Value			
					Total		Percentage distribution	
	Oil	Meal 2/	Oil	Meal	Oil	Meal 4/	Oil	Meal 5/
	Pounds	Pounds	Cents	Cents	Dollars	Dollars	Percent	Percent
Average:								
1931-35	8.5	48.5	5.8	1.4	0.49	0.70	41	59
1936-40	9.1	47.9	6.3	1.5	.57	.74	44	56
1941-45	8.9	48.1	11.7	2.5	1.04	1.21	46	54
1946	9.0	48.0	22.8	4.1	2.05	1.95	51	49
1947	9.5	47.5	23.7	4.6	2.25	2.18	51	49
1948	9.8	47.2	13.1	3.8	1.28	1.80	42	58
1949	9.9	48.0	12.3	3.7	1.22	1.79	41	59
1950	9.7	47.6	17.8	3.8	1.73	1.83	49	51
1951	10.0	47.6	11.3	6/ 4.8	1.13	2.29	33	67

1/ Industry averages.

2/ 1931-48 computed by taking 95 percent of total weight (60 pounds) of a bushel of soybeans minus the yield of oil; thereafter computed from data reported by the Bureau of the Census.

3/ Simple average price per pound, year beginning October, using the following quotations: Soybean oil, crude, tank cars, f.o.b. midwestern mills; soybean meal, bagged, Chicago, quoted as 41-percent protein beginning November 1936, 44-percent protein beginning July 1950.

4/ Based on unrounded price data.

5/ The value of the meal has an upward bias relative to the value of the oil, as the price of meal used in the computations includes, among other things, the costs of bagging and of transportation from midwestern mills (where the soybean oil is priced) to Chicago. The extent of the bias depends upon the relative importance of these cost items to the total price. Use of the bulk, Decatur, soybean meal price series (only available since 1940) reduces the percentage which meal is of the total value by 3 to 4 points.

6/ April-September prices used in this computation were for soybean meal mix.

Compiled from reports of the Bureau of the Census, the Production and Marketing Administration, and the Oil, Paint and Drug Reporter (15).

percentage of foreign material. However, the relationship apparently depends upon the type of foreign material present. 5/ Likewise, the many types of damage vary in their effects on the quantity of crude oil obtained. Split soybeans were found to contain more oil than whole sound soybeans, as split soybeans have lost part of their seed coat, which is relatively low in oil. The presence of split soybeans in a bushel of soybeans, therefore, should tend to increase the oil content. The effect of this on the value of a bushel of soybeans, however, is largely offset by the fact that splits adversely affect the quality of the oil. 6/

Factors that Affect Yields of Meal

The yield of soybean meal per bushel of soybeans processed depends primarily upon the oil content of soybeans. The higher the oil content, the smaller the quantity of meal produced. The yield of meal, like that of oil, is affected also by the percentage of foreign material in a bushel of soybeans and the moisture content. These factors are related to the amount of loss that occurs in processing soybeans. Processing loss varies from season to season and from mill to mill.

Soybeans and therefore soybean meal are high in protein. In commercial varieties of soybeans, the protein content usually ranges between 40 and 45 percent on a moisture-free basis. Apparently it varies inversely with the oil content. 7/

RELATIONSHIPS INVOLVED IN MEASURING EFFECTS OF INCREASED YIELDS OF SOYBEAN OIL ON PRICES, TOTAL RETURNS, AND OTHER FACTORS

Changes in yields of soybean oil and meal tend to cause changes in related economic factors. Prices and total returns from marketing soybeans and soybean products are affected. A diagram of the economic factors that are affected by

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5/ Types of foreign material that contain oil include seeds of cocklebur, morning glory, horsenettle, groundcherry, and the cultivated grains. Types of foreign material that do not contain significant quantities of oil include sticks, pods, and stems. See Keirstead (9).

6/ For a consideration of the effect of grade factors on the quality of oil, see Keirstead (9) and Rollefson, Agnew, and Keirstead (17).

7/ Pahigian (16), on the basis of an analysis of data from the 1945, 1946, and 1947 soybean crops, tentatively concluded that oil content generally tends to increase and protein content to decrease from north to south. Keirstead (9), in a similar analysis of data from the 1949 and 1950 soybean crops, found that oil content increased from northern areas to as far south as central Illinois and central Indiana. Soybeans from southern Illinois and southern Indiana were low in oil content.

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a change in the yield of soybean oil and meal is presented in figure 1. 8/ Each box in the diagram represents one or more of the economic variables involved. Arrows indicate the direction of the various influences. Boxes bound by dashed lines represent factors that logically belong in the diagram but upon which the effects of changes in yield could not be statistically measured.

The effect of a change in the yield of both soybean oil and meal operates initially through changes in supply and value. Changes in the supply of soybean oil tend to affect mainly economic factors associated with the food fats and oils economy. Changes in the supply of soybean meal impinge mainly on the feed-livestock economy. The combined effect of changes in yield on the value of oil and meal is traced in the middle section of the diagram. In the discussion that follows, the economic factors affected by changes in yield and the paths along which the influences travel are considered in greater detail. For illustrative purposes, the discussion is in terms of an assumed increase in the yield of soybean oil.

As a dual purpose oil, soybean oil holds an intermediate position between the nonedible drying oils (for example, linseed oil) and the edible nondrying oils (for example, cottonseed oil). Mainly because of its chemical composition, soybean oil is suitable for certain uses in both edible and nonedible products. This characteristic permits some shifting of soybean oil from use to use as economic and technological circumstances dictate. Although originally valued mainly for its drying properties, in almost every year since 1935 more than 80 percent of the soybean oil consumed domestically has gone into edible products. Consequently, the price of soybean oil would be determined chiefly by the supply and demand of edible fats and oils. The quantities used in nonfood products in any year depend mainly upon factors not directly related to the food fats and oils economy. For example, more than 150 million pounds of soybean oil were used annually by the drying-oil industries during 1947-49, compared with the previous high of 67 million pounds in 1946. The increased usage in these years reflected mainly the high Government-support price for flaxseed and the resulting wide differential between prices of soybean oil and those of linseed oil.

As increase in the yield of soybean oil results in an increase in production of the oil. As a high degree of interchangeability exists among the fats and oils that can be used in food products, users are ordinarily more interested in the total supply of edible fats and oils than in the supply of any individual fat or oil. 9/ Consequently, the economic effects of changes

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8/ This diagram is similar to the one developed by Armore (1) which represented the factors affected by changes in the yield of cottonseed oil. The discussion follows similar lines.

9/ For a discussion of the relationships between edible fats and oils, see Armore (1).

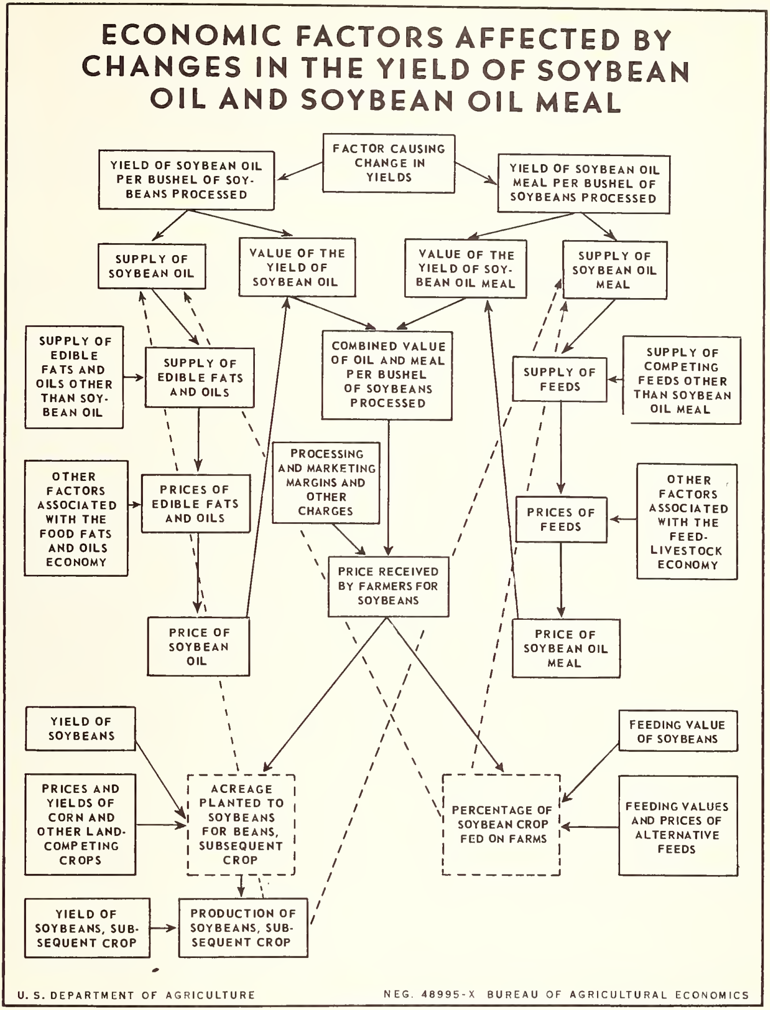

Figure 1.- A change in the yield of soybean oil would primarily affect the economic factors associated with the food fats and oils economy. The economic effects of a change in the yield of soybean meal would be felt chiefly in the feed-livestock economy. The net effect on the price received by farmers for soybeans would reflect changes in both prices and yields of the oil and meal.

in the supply of soybean oil would operate through the resulting changes in the total supply of fats and oils, other than butter and lard, used in food products. 10/

An increase in the total supply of these fats and oils would tend to reduce their prices, including that of soybean oil. However, the price-depressing effect of an increase in the supply of soybean oil would be cushioned by the fact that the percentage rise in total supply of food fats and oils would be smaller than for soybean oil alone. Variables that affect the price of fats and oils, other than butter and lard, used in food products are discussed in Armore (1).

The price and yield of soybean oil together determine the value of the yield. An increase in yield would tend to increase the value. This tendency, however, would be offset to some extent by the lower price for soybean oil that would result from the increase in supply.

An increase in the yield of soybean oil is likely to be accompanied by a decrease in the yield of soybean meal. This would result in a decrease in production of soybean meal. Ordinarily more than 90 percent of the supply of soybean meal finds an outlet as a protein supplement in livestock feeding. Although quantities used for other purposes (for example, as a food or a source of industrial protein) could expand, such uses are not important from a price-influencing standpoint. In the feed market, soybean meal competes most directly with several other protein feeds. 11/ These protein feeds probably should be treated as a single commodity in ascertaining the effect on price of a change in the supply of soybean meal. Soybean meal also competes in the feed market with other feed concentrates, including grains and various byproduct feeds. 12/ Hence, a reduction in the supply of soybean meal would affect, in addition to its own price, the prices of all feeds with which it competes. However, a given percentage reduction in the supply of soybean meal represents a smaller percentage decrease in the total supply of competing feed concentrates. Consequently, the price-increasing effect of such a reduction would be less than it would have been had soybean meal been without close substitutes. Factors that affect the price of feed concentrates in general are discussed in Foote, Klein, and Clough (5).

10/ The principal fats and oils, other than butter and lard, used in food products include cottonseed, soybean, peanut, corn, olive, oleo and coconut oils, tallow, oleostearine, and oleo stock. Reasons for the omission of butter and lard are discussed in Armore (1).

11/ These feeds include primarily the oilseed meals, such as cottonseed, linseed, and peanut meal, and the animal proteins, such as tankage, meat scraps, and fish meal.

12/ It has been stated, for example, that when prices of soybean oil meal are similar to prices of grains, the meal can be fed advantageously to cattle at ratios of 1 part soybean meal to 4 or even 2 parts corn, instead of the conventional 1 part soybean meal to 7 parts corn. See Markley (10, v. 2, pp. 928-929).

The value of the yield of soybean meal is determined by yield and price. A reduction in yield tends to lower the value of the meal. But the decreased supply would be likely to increase its price and thus its value. The net effect of these divergent influences on value would depend upon the exact amount of the change in price and yield.

The values of the soybean oil and meal together represent the value of the products obtained from processing a bushel of soybeans. As is shown later, the price received by farmers for soybeans in the past has been closely related to the combined value of the oil and meal obtained per bushel of soybeans processed.

A part of the soybean crop is retained on farms each year for use as seed and as feed for livestock. The remainder is sold to be processed for oil and meal, or to be exported, processed for direct use as food for human consumption, or used as seed or feed on farms other than those on which it is produced. Since the late 1930's, more than 80 percent of the soybeans sold have been crushed.

Table 2 shows the production and farm disposition of soybeans since 1926. After allowing for planting needs, producers have sold most of the crop and fed the rest on their own farms. As a percentage of the crop less the amount used for seed on farms where grown, quantities sold averaged 76 percent in 1926-30, 92 percent in 1936-40, and ranged between 98.6 and 99.3 percent during 1946-52.

Although changes in the price received by farmers for soybeans may affect the percentage of the crop sold, this was not confirmed statistically. Before World War II, the relationship was obscured by factors associated with the establishment and expansion of soybeans as a cash crop. In the postwar period, when soybeans were subject to influences more normal to a well-established commodity, year-to-year changes in percentage of the crop sold were never greater than two-tenths of one percent.

Theoretically, changes in the price received by farmers for soybeans may affect somewhat the percentage of the crop sold, because of their effect on the economy of using soybeans as a feed. To a certain extent, soybeans can substitute for various feed concentrates in livestock rations. According to Henry and Morrison (7), soybeans are richest in protein of all common seeds and they rank even above corn in total digestible nutrients, mainly because of their high fat content. Moreover, feeding experiments have indicated that soybeans are valuable as a high-protein feed which farmers can produce at moderate cost and can use to fill at least a part of their feed requirements. 13/ Farmers with soybeans of feeding quality may determine the extent to which it is economically practicable to use them as livestock feed. This may be done by taking into consideration, in addition to the type of livestock to be fed, the relative

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13/ For a discussion of the use of soybeans as feed for livestock, see Morse and Cartter (11, pp. 11-14) and Markley (10, v. 2, ch. 22).

Table 2.- Soybeans: Production and farm disposition, averages 1926-45, annual 1946-52 1/

Period	Production	Used on farms where grown 2/		Production, less quantity used as seed on farms where grown	Quantity sold 4/	Percentage of production less quantity used as seed on farms where grown	
		For seed 3/	Fed to livestock			Sold 5/	Fed to livestock 5/
	Million bushels	Million bushels	Million bushels	Million bushels	Million bushels	Percent	Percent
Average:							
1926-30	8.7	1.2	1.8	7.5	5.7	76.3	23.7
1931-35	23.6	2.7	2.6	20.9	18.3	87.4	12.6
1936-40	62.0	6.4	4.2	55.6	51.4	92.5	7.5
1941-45	174.0	10.7	4.5	163.3	158.8	97.2	2.8
1946	203.4	11.2	2.7	192.2	189.5	98.6	1.4
1947	186.4	10.4	2.5	176.0	173.5	98.6	1.4
1948	227.2	10.5	2.8	216.7	213.9	98.7	1.3
1949	234.2	11.3	2.5	222.9	220.4	98.9	1.1
1950	299.3	12.4	2.5	286.9	284.4	99.1	.9
1951	282.5	12.4	2.0	270.1	268.1	99.2	.8
1952 6/	291.7	12.9	2.0	278.8	276.8	99.3	.7

1/ Disposition of the crop specified and not disposition within the marketing year. Estimates of farm disposition represent portions of the crop used or to be used for the designated purposes on farms where produced and do not include purchases by farmers from others for such purposes.

2/ Assumes no change in stocks of soybeans on farms.

3/ Used for planting crop of succeeding year.

4/ Includes sales for crushing, export, direct use as food, and to other farmers.

5/ Based on unrounded data.

6/ Preliminary.

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prices of available feed concentrates, and their relative feeding value. 14/ In any given year, therefore, changes in the market price of soybeans may make it more or less economical for farmers to use soybeans as feed and any actions taken as a result would affect the percentage of the crop sold. With consistently high relative prices for soybeans, it would be expected that all or virtually all of the soybean crop, after allowance for planting requirements, would be sold.

For all practical purposes, the recent high levels in percentage of the crop sold may be considered a maximum, as the remaining percentage may go into feed uses largely fixed by factors such as custom and convenience. (During 1946-52, the quantity of soybeans fed to livestock on farms where produced kept within a narrow range of 2.0 to 2.8 million bushels, despite a marked increase in production.) In the postwar years, although prices of soybeans fluctuated considerably, apparently it was more economical for farmers to sell most of their soybeans than to feed more of them to livestock. The percentage of the crop sold during this period remained essentially unchanged at or about the apparent maximum (table 2). Thus, any great change in percentage of the crop sold from current high levels would need to be on the down side. As there is little reason to expect any significant change in the relatively small volume of soybeans fed on farms where produced, the quantity of soybeans used for crushing is likely to depend primarily upon the size of the crop and the quantity of soybeans exported.

Prices received by farmers for soybeans may affect production in subsequent years. In certain areas, soybeans compete for land with crops such as corn, oats, hay, wheat, and cotton. This competition is most important in the Corn Belt 15/ where most of the soybeans are grown. As a general rule, since 1930 this area has accounted for more than 70 percent of the total acreage harvested for beans and more than 60 percent of the total acreage planted for all purposes. This is true even though expansion of acreage in other soybean-producing areas has been relatively greater since about the middle 1940's.

Farmers ordinarily have enough leeway to make intercrop adjustments, if conditions warrant them. Thus, a relatively permanent change in prices of soybeans relative to prices of competing crops, such as might result from changes in yields of soybean oil, would be likely to affect acreage and production of soybeans or the rate of expansion. Although such responses to changes in the relationship between prices have been apparent, they are difficult to measure statistically. This is mainly because of the relatively short historical record available for study and the fact that this record covers chiefly the period in which soybeans were a new and rapidly expanding commodity. 16/

14/ For a discussion of several methods of deciding upon the most economical feed ration, see Henry and Morrison (7, ch. 12).

15/ Including Illinois, Iowa, Indiana, Ohio, and Missouri.

16/ For a discussion of the relationship between soybeans and competing crops, and the effect on soybean acreage and production of several alternative sets of relative prices, see Strand (20).

In addition to their economic value as seed for crushing, soybeans are grown for forage and for green manure. Acreage harvested for beans did not exceed acreage for forage until 1941. In most of the postwar period, however, over 80 percent of the acreage planted has been harvested for beans. Any change in the proportion of the total acreage that is harvested for beans affects production of soybeans. This, in turn, affects production of soybean oil and meal.

Production of soybeans also may be affected by changes in price relationships between planting and harvest time. Production of soybeans for crushing is limited chiefly to acreages planted to yellow varieties of the soybean seed. Hay varieties of soybeans differ from commercial varieties in several ways (for example, in oil content). But under some circumstances, hay varieties may be grown to maturity for seed to be crushed and yellow varieties may be cut early for use as hay. 17/ Such changes in end use of soybeans would depend primarily upon anticipations concerning prices of soybeans and upon the need for hay. Data for measuring such shifts in the purpose of the crop between planting and harvest time are not available.

ANALYSES NEEDED TO MEASURE NET EFFECTS OF INCREASED YIELDS OF SOYBEAN OIL ON PRICES AND TOTAL RETURNS FOR SOYBEANS

Material presented in the preceding section has indicated how changes in the yield of soybean oil and meal affect related market factors. In this section, statistical analyses are presented that can be used to make quantitative estimates of these effects. To provide a framework within which use of the analyses can best be illustrated, some consideration first is given to methods of processing in current use. Following this, the effects of method of processing on yields of soybean oil and meal are indicated.

Methods of Processing Soybeans

At present, three methods are used in the United States to separate soybeans into oil and meal: Hydraulic pressing, continuous pressing (screw presses), and solvent extraction. 18/ The first two methods come under the general head of mechanical processing. The latter involves the use of volatile fat solvents for extracting the oil from the seed.

Hydraulic presses have only a limited place in normal operations of the soybean-processing industry. Oil mills using hydraulic presses are or have been engaged primarily in processing other oilseeds, such as flaxseed or cottonseed. Increased use of hydraulic presses for soybean processing during World

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17/ See Markley (10, v. 1, p. 94). For a discussion and description of varieties of soybeans, see Morse, Cartter, and Williams (13). For a discussion of production of soybeans for hay and beans, see Morse, Cartter, and Hartwig (12)

18/ For a discussion of the steps involved in processing soybeans by these methods, see Markley (10, v. 1, ch. 14; v. 2, ch. 15).

War II reflected mainly the shortages in processing capacity. In 1951-52 hydraulic presses processed about 3.5 million bushels, or only slightly more than 1 percent of the total soybean crush.

Removal of oil from the seed by use of continuous screw presses was the major method of processing soybeans until 1949. Among other advantages, operating costs per unit crushed were generally lower and yields of oil generally higher than for hydraulic presses. During the 1936-46 crop-years, the number of bushels crushed by continuous screw presses increased from 14 million to almost 109 million. Of the total crush, screw presses processed between 63 and 74 percent. However, as the use of solvents continued to expand, the percentage of the total crush processed by screw presses declined to about 55 percent during the 1947 and 1948 crop-years, 41 percent in 1949-50, and 25 percent in 1951-52.

Since the introduction of solvent extraction, the quantity of soybeans handled by solvent plants has steadily increased. From less than 3 million bushels in 1936-37 it rose to more than 109 million bushels in 1949-50 and to almost 179 million bushels in 1951-52. As a percentage of the total soybean crush, the quantities processed by solvents rose from 13 percent in 1936-37 to 28 percent in 1945-46, 56 percent in 1949-50, and 74 percent in 1951-52. The principal advantage of solvent extraction is its greater efficiency in recovery of oil. Moreover, soybeans are well suited to solvent extraction. 19/ These advantages, plus the fact that the oil has been worth more per pound than the meal, have apparently more than offset any disadvantages the solvent method may have with respect to costs of installation and operation.

Table 3 shows the advantage of solvent extraction over the screw-press method in terms of value of products obtained per bushel of soybeans processed. This advantage is greater when prices of oil are high in relation to prices of meal than when they are low. Consequently, the declining ratio of prices of oil to prices of meal during the first half of the 1951-52 marketing year is reflected in a narrowing of the economic advantage enjoyed by the solvent method. Apparently, however, that tendency since has been reversed. In general, the difference in value of products obtained is one of the principal causes for the continuing shift from mechanical methods to the solvent method of processing.

Figure 2 shows the growth of the soybean-processing industry since 1936 in terms of the quantities of soybeans crushed and the varying trends in the quantities crushed by each method of processing.

19/ For a brief discussion of the application of solvent extraction to various oil-bearing materials, see Bailey (3, pp. 577-580).

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Table 3.- Value of products obtained per bushel of soybeans processed, by specified method of processing, annual 1947-51, by months, 1951 to date

Year beginning October	Method of processing						Additional value obtained with solvent extraction
	Screw press			Solvent extraction			
	Oil 1/	Meal 2/	Total	Oil 1/	Meal 2/	Total	
	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
Annual:							
1947	2.11	1.95	4.06	2.53	1.87	4.40	0.34
1948	1.20	1.58	2.78	1.43	1.52	2.95	.17
1949	1.10	1.57	2.67	1.32	1.52	2.84	.17
1950	1.53	1.58	3.11	1.87	1.52	3.39	.28
1951	.97	2.04	3.01	1.19	1.96	3.15	.14
1951							
Oct.	1.18	3/1.81	2.99	1.45	3/1.74	3.19	.20
Nov.	1.13	3/1.81	2.94	1.39	3/1.74	3.13	.19
Dec.	1.08	3/1.81	2.89	1.33	3/1.74	3.07	.18
Jan.	.96	3/1.81	2.77	1.18	3/1.74	2.92	.15
Feb.	.92	3/1.81	2.73	1.13	3/1.74	2.87	.14
Mar.	.87	3/1.81	2.68	1.07	3/1.74	2.81	.13
Apr.	.78	4/2.05	2.83	.96	4/1.97	2.93	.10
May	.87	4/2.17	3.04	1.06	4/2.08	3.14	.10
June	.96	4/2.28	3.24	1.18	4/2.19	3.37	.13
July	.97	4/2.28	3.25	1.19	4/2.19	3.38	.13
Aug.	.99	4/2.54	3.53	1.21	4/2.44	3.65	.12
Sept.	.96	4/2.29	3.25	1.18	4/2.20	3.38	.13
1952							
Oct.	.93	1.99	2.92	1.15	1.91	3.06	.14
Nov.	1.01	1.83	2.84	1.24	1.76	3.00	.16
Dec.	1.11	1.76	2.87	1.36	1.69	3.05	.18
Jan.	1.09	1.66	2.75	1.34	1.60	2.94	.19
Feb.	1.08	1.59	2.67	1.33	1.53	2.86	.19
Mar.	1.16	1.63	2.79	1.42	1.56	2.98	.19

1/ Price per pound of crude oil, tanks, f.o.b. midwestern mills times corresponding yield of oil per bushel shown in table 4. 1951 yields used in 1950 and 1952.

2/ Price per pound of meal, bulk, Decatur (41-percent protein before July 1950, 44-percent protein thereafter) times corresponding yield of meal per bushel shown in table 4. 1951 yields used in 1950 and 1952.

3/ Ceiling price.

4/ Prices of soybean meal mix used in this computation as most soybean meal in these months was sold in this form.

Compiled from reports of the Bureau of the Census, the Production and Marketing Administration and the Oil, Paint and Drug Reporter (15).

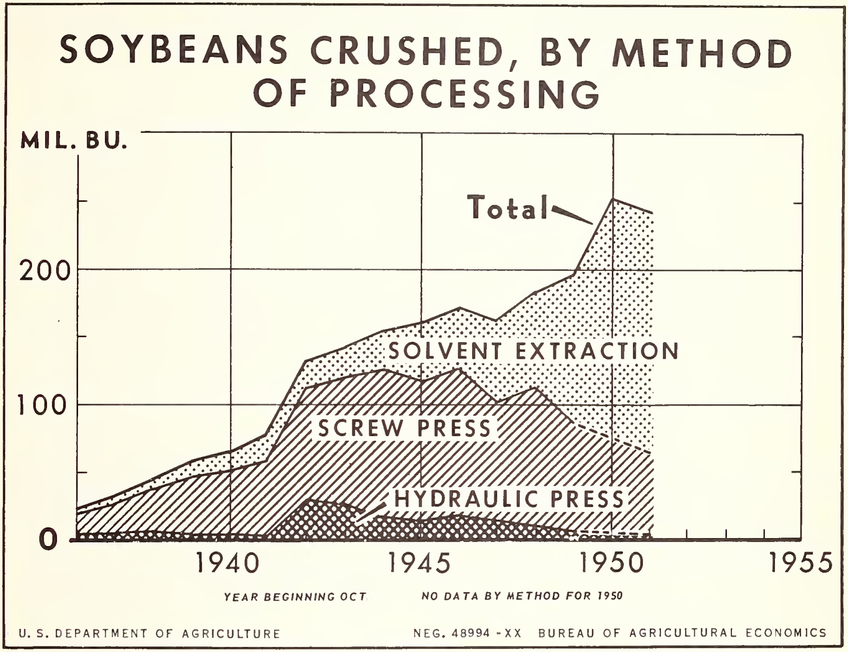

Figure 2.- Solvent extraction is now the most important of the three methods used to process soybeans. In 1951-52 solvents were used to process almost 74 percent of the total soybean crush. This chart is based on data collected by the Bureau of the Census, in cooperation with the United States Department of Agriculture, through the Northern Regional Research Laboratory of the Bureau of Agricultural and Industrial Chemistry and the Production and Marketing Administration.

Effect of Method of Processing on Yields of Oil and Meal

Table 4 compares yields of oil and meal per bushel of soybeans processed during the 1947-49 and 1951 crop-years by method of processing. The figures for yields of meal are computed as indicated in the footnote to the table. Processing loss per bushel of soybeans is assumed to be the same each season for each type of processing equipment.

The tendency for oil yields by the two major methods to change in the same direction during 1947-49 and 1951 may be ascribed mainly to changes in oil content of the seed from season to season. But the differences in yields for each of the methods reflect the relative efficiencies of these methods in extracting oil. As a result of the increase in solvent extraction, however, average yields of oil for the industry moved upward during this period.

The superiority of solvent extraction in oil recovery is readily apparent. On the average, the solvent process during the 1947-49 and 1951 crop-years recovered about 1.8 more pounds of oil per bushel of soybeans than the screw-press process and about 2.2 more pounds than the hydraulic-press process. In percentage terms, the solvent process was 20 percent more efficient in oil recovery than screw presses and about 26 percent more efficient than hydraulic presses.

Most of the oil present in the seed can be recovered by use of solvent extractors. Under the conditions delineated in table 5, the solvent process in 1949 would have extracted about 97 percent of the oil in a bushel of soybeans compared to about 81 percent for the screw-press process and about 76 percent for the hydraulic-press process. The residual oil in the meal is reduced to less than 1 percent, whereas 4 to 5 percent generally remains following use of screw presses and 5 to 6 percent following use of hydraulic presses.

As the additional oil recovered by solvent extraction is taken at the expense of the quantity of residual oil in the meal, yields of meal per bushel of soybeans processed are reduced. On the basis of the 1947-49 and 1951 average yields of meal shown in table 4, the solvent process produced about 4 percent less meal than the screw-press process and about 5 percent less than the hydraulic-press process.

Although the solvent process reduces yields of meal per bushel of soybeans, at the same time it tends to create a product with a higher percentage of protein. On the feed market, soybean oil meal is designated by a guaranteed percentage of protein and by the process employed in oil recovery. Solvent-extracted soybean meal is usually sold with a 44-percent protein guarantee; mechanically processed meals with a 41-percent protein guarantee. Standard specifications for mechanically processed and solvent-extracted soybean meals are shown in table 6. After the oil is removed from the seed, the residue may be adjusted to the specified protein content by the addition of moisture (3, p. 526). As indicated in table 6, however, the moisture content of the standard grades of soybean meal used as feed is limited to 12 percent. Results of analyses of the composition and digestible nutrients of soybeans,

Table 4.- Soybean oil and meal: Yield per bushel of soybeans processed by method of processing, 1947-49 and 1951 1/

Year beginning October	Method of processing: Hydraulic press		Screw press		Solvent extraction		Industry-average	
	Oil	Meal 2/	Oil	Meal 2/	Oil	Meal 2/	Oil	Meal 2/
	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
1947	8.46	48.54	8.86	48.14	10.67	46.33	9.51	47.49
1948	8.67	48.33	9.16	47.84	10.94	46.06	9.84	47.16
1949	8.38	49.52	8.96	48.94	10.73	47.17	9.93	47.97
1951 3/	8.39	49.16	8.57	48.98	10.52	47.03	10.00	47.55
Average	8.47	48.89	8.89	48.47	10.71	46.65	9.82	47.54

1/ Data on yields by method of processing are not available for the 1950 crop-year nor for crop-years prior to 1947.

2/ 1947 and 1948 yields of meal were computed for each method of processing and for the industry-average by subtracting the corresponding yield of oil and 3 pounds for processing loss from a 60-pound bushel of soybeans. Since 1949, industry-average yields of meal can be computed from reports of the Bureau of the Census. Yields of meal for each method of processing in 1949 and 1951 were computed in the same way as in 1947 and 1948, except that the processing loss used was determined by subtracting the combined industry-average yield of oil and meal from a 60-pound bushel of soybeans.

3/ Preliminary.

Compiled from reports of the Bureau of the Census and the Production and Marketing Administration.

Table 5.- Soybean oil and meal: Yield per bushel of soybeans of specified composition, by method of processing, and changes associated with solvent extraction, 1949 1/

Item	Unit	Method of processing		
		Hydraulic press	Screw press	Solvent extraction
Yield:				
Oil 2/				
Quantity	Pound	8.1	8.7	10.4
Percentage of oil content	Percent	75.7	81.3	97.2
Meal 3/	Pound	49.8	49.2	47.5
Oil remaining in meal				
Quantity	do.	2.6	2.0	.3
Percentage	Percent	5.2	4.1	.6
Estimated loss in processing 3/	Pound	2.1	2.1	2.1
Changes associated with use of solvent extraction:				
Increase in yield of oil				
Quantity	do.	2.3	1.7	---
Percentage	Percent	28.4	19.5	---
Decrease in yield of meal				
Quantity	Pound	2.3	1.7	---
Percentage	Percent	4.6	3.5	---

1/ Average composition of a 60-pound bushel of soybeans assumed to be as follows: Oil, 10.7 pounds; solids (protein, fiber, ash, etc.), 42.0 pounds; and moisture, 7.3 pounds. These data are based on results of analysis of 668 samples of soybeans grown in the major producing areas in the United States during the 1949 crop-year as reported by Keirstead (9).

2/ Average 1949 yields of oil (table 4) reduced by 0.3 pounds. Most of the soybean samples referred to in footnote 1 were collected in November and December 1949. Data on yields of soybean oil by method of processing, however, are not available on a monthly basis. Hence, in order to obtain greater comparability with the sample data on soybean composition, the average 1949 crop-year yields of oil by processing method were adjusted by the amount of the difference between the industry-average yield of oil for November-December 1949 as computed from reports of the Bureau of the Census and the industry-average yield of oil for the entire 1949 crop-year.

3/ Average yield of meal computed for each method of processing by deducting the corresponding yield of oil and 2.1 pounds for processing loss from a 60-pound bushel of soybeans. Processing loss was found by subtracting the combined industry-average yield of oil and meal as compiled from reports of the Bureau of the Census from a 60-pound bushel of soybeans.

Based partly on reports of the Bureau of the Census and the Production and Marketing Administration.

mechanically processed meals, and solvent-extracted meal are shown in table 7. It may be noted that the protein content of the meals analyzed (table 7) exceeded their minimum specifications (table 6). Both tables indicate the varying effects of the solvent and mechanical methods of processing on the composition of soybean meal.

In its earlier years on the market some prejudice existed against the use of solvent-extracted meal in livestock rations. This was mainly because its oil content was regarded as too low and some solvent tended to remain in the meal. As a result, solvent-extracted meal often sold at a discount. Methods for removing the solvent have since been perfected. Processes have been developed that enhance the nutritional value of the meal and improve its digestibility, palatability, and appearance. As shown in table 7, the solvent-extracted meal, despite its lower fat content, is apparently as high in total digestible nutrients as mechanically processed meals. The solvent-extracted meal is now more readily accepted by users. But the mechanically processed meals, apparently because of their extra oil content, still command a premium over the solvent-extracted meal at times.

Although no quantitative data on this price differential are available in any consistent form, some information for the post-World War II years has been gathered from several published and unpublished sources. In a recent study of soybean marketing in Illinois by Sabin (18), it was reported that during the 1947-48 crop-year solvent-extracted meal frequently sold at $1.00 or more a ton below screw-press soybean meal. This would be equivalent to a discount of about 2 percent. During the 1948-49 crop-year, the discount on solvent-extracted meal is reported to have averaged somewhat lower. Limited information available for 1949 indicates that in several markets average discounts on the solvent-extracted meal ranged approximately between $0.95 and $1.40 a ton. There is also some evidence that the solvent-extracted meal sold at prices either the same as or higher than those of mechanically processed meals during several months of 1950. Ceiling prices established by the Office of Price Stabilization in 1951 and 1952 were the same for both 41- and 44-percent soybean meal (22). In the 1951-52 marketing year, there was no indication of either discounts or premiums for the solvent-extracted meal. During that period both types of meal sold at ceiling prices. However, in the first few months of 1953, screw-press soybean meal was quoted at a premium of as much as $3.50 a ton above solvent-extracted meal (24). Discounts on the solvent-extracted meal would partly offset the value of the higher yield of oil from the solvent process.

As a source of industrial protein, the solvent-extracted soybean meal is generally the more suitable of the two types. It has a higher protein content and a greater protein solubility than the meals produced by hydraulic or mechanical pressure. Although the quantity of soybean protein used currently for industrial purposes is of little importance, such use could expand in the future. The degree of expansion or contraction will depend chiefly on economic and technological developments. 20/

20/ For a discussion of the industrial uses of soybean meal and protein, see Markley (10, v. 2, ch. 24), Shollenberger and Goss (19, pp. 77-78), and the report of Arthur D. Little, Inc. (2).

Table 6.- Standard specifications for soybean oil meal used for livestock feed, by method of processing

Constituent	Soybean oil meal: Solvent process	Soybean oil meal: Screw or hydraulic press process
	Percent	Percent
Protein, minimum	44.0	41.0
Fat, minimum	.5	3.5
Fiber, maximum	7.0	7.0
Nitrogen-free extract, minimum	27.0	27.0
Moisture (when shipped by seller), maximum	12.0	12.0

National Soybean Processors Association (14).

Table 7.- Average composition and digestible nutrients of soybeans and of soybean oil meals produced by specified methods of processing

Constituent	Soybeans	Soybean oil meal: Solvent process	Soybean oil meal: Screw or hydraulic press process 1/
	Percent	Percent	Percent
Protein	37.9	46.1	44.3
Fat	18.0	1.0	5.3
Fiber	5.0	5.9	5.7
Nitrogen-free extract	24.5	31.8	29.6
Mineral matter	4.6	5.8	6.0
Moisture	10.0	9.4	9.1
Total	100.0	100.0	100.0
Digestible protein	33.7	42.4	37.2
Total digestible nutrients	87.6	78.5	78.4

1/ Henry and Morrison (7) use the term "expeller" instead of the term "screw."

Compiled from data reported in Henry and Morrison (7).

Effect of Changes in Yield of Soybean Oil on the Supply and Price of Soybean Oil Meal

Based on the 1947-49 average yields of meal per bushel of soybeans crushed the use of screw presses only to handle the 1947-49 average soybean crush of 172 million bushels would have increased the average supply of soybean meal for that period by about 65,000 tons, or 1.6 percent. 21/ Use of only solvent extractors, on the other hand, would have resulted in a reduction in supply of about 85,000 tons, or 2.1 percent. Soybean meal competes in the market place primarily with other feeds containing a high percentage of protein. Consequently, in ascertaining the economic effects of a change in the supply of soybean meal, the resulting change in the supply of these feeds must be taken into account.

On the basis of the 1947-49 average supply of 8,033,000 tons of closely competing protein supplements 22/, the 1.6-percent increase in the supply of soybean meal would result in an 0.8-percent increase in the supply of these protein feeds. The 2.1-percent decrease, on the other hand, is equivalent to a 1.1-percent decrease in the supply of these protein supplements. Soybean meal also competes to some extent with other feed concentrates. These changes in the supply of soybean meal would amount to less than one-tenth of 1 percent of the 1947-49 average supply of all feed concentrates--158.5 million tons. When data for more recent years are used, changes are also small.

Such small changes in supply would be expected to affect price very little. Foote, Klein, and Clough (5) indicate that a change of one-tenth of 1 percent in supply of all feed concentrates would be associated, on the average, with a change of about two-tenths of 1 percent in price in the opposite direction. Such a change in price would not be significant. This study indicates an elasticity of demand for total feed concentrates of between -0.4 and -0.5.

Soybean meal probably competes more closely with other protein feeds than with all feed concentrates. Consequently, consideration of the effect on price of changes in the supply of competing protein feeds may be more meaningful from an economic standpoint. Jordan (8) ran an analysis of the factors that affect prices of protein supplements, based on data for 1935-41 and 1946-48. He indicated that a 1-percent change in production of protein supplements (meal-equivalent basis) per grain-consuming animal unit (except horses and mules) is

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21/ Excludes soybeans estimated as crushed specifically for flour and oil. The data needed to estimate yields of meal by method of processing for the 1951-52 crop-year (table 4) were not available in time for use in these computations. The 1947-49 average yield of meal was 48.3 pounds per bushel for screw presses and 46.5 pounds for solvent extraction.

22/ Average quantity estimated as used for feeding. Protein feeds included in this category and their 1947-49 average supply in 1,000 tons are as follows: Oilseed cakes and meals (soybean, 4,019; cottonseed, 2,202; linseed, 632; and peanut, 104) and animal proteins (tankage and meat scraps, 840; and fish meal, 236).

associated with an opposite change of 0.43 percent in the weighted composite price of protein supplements. 23/ This price-supply relationship implies an elasticity of demand for protein supplements per animal unit of about -2.3.

Protein supplements may be considered collectively as a competing member in the total supply of feed concentrates. It would be expected that, on the average, the demand for such a member would be more elastic than the demand for the group as a whole. However, the large difference between the demand elasticity of protein supplements (as implied by Jordan's analysis) and of all feed concentrates (as given by Foote, Klein, and Clough) indicates the need for further study. Such a task is beyond the scope of this report. The analysis by Jordan was based on only 10 years of data. Also, the standard error of the regression coefficient for supply of protein supplements apparently was relatively large.

Jordan's analysis may be used to indicate roughly the effects on price of changes in production of protein supplements (meal-equivalent basis) per animal unit that would result from industry-wide use of alternative processing methods for soybeans. For example, use of only solvent extractors would result in about a 1-percent decrease in the 1947-49 average production of protein supplements (meal-equivalent basis) per animal unit. This, in turn, would result in about an 0.7-percent increase in the composite price of protein supplements, other things remaining at their 1947-49 level. A similar increase would be expected in the price of soybean meal. Although this estimate is rough, it is apparent that the change would be negligible. The equations presented in the remainder of this report assume that changes in supply that would result from industry-wide use of alternative processing methods would not significantly affect the price of soybean meal. A more refined analysis of the factors that affect prices of protein supplements will be needed if the methods presented here are used to study factors that could change production of soybean meal enough to affect its price significantly.

Factors that Affect Prices of Fats and Oils, other than Butter and Lard, Used in Food Products 24/

The factors found to explain most of the annual variation in prices of edible fats and oils, other than butter and lard, were: (1) The per capita

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23/ In Jordan's study, adjustments to a meal-equivalent basis are made by converting protein supplements to a common protein base. Protein supplements included are soybean meal, cottonseed meal, linseed meal, copra meal, peanut meal, gluten feed and meal, tankage, meat scraps, and fish meal. The composite price of protein supplements is weighted by the production of each protein supplement converted to a meal-equivalent basis.

24/ Material in this section is taken from the discussion and results of an analysis made by Armore (1). For a full discussion the reader is referred to that source. Pertinent statistical coefficients relating to this analysis are shown in footnote 28, Appendix note 2.

supply of fats and oils, other than butter and lard, used in food products; (2) the per capita supply of lard; and (3) personal disposable income per capita. In an analysis based on the calendar years 1922-42 and 1947-51, these three variables together accounted for 92 percent of the variation in price. The analysis may be used to determine the probable effect of a change in the supply of soybean oil on prices of soybean oil and of other fats and oils used in food products.

Individual relationships between the price of fats and oils, other than butter and lard, used in food products and each independent factor, after allowing for the influence of the other independent factors, were as follows: (1) A 1-percent change in per capita supply of fats and oils, other than butter and lard, used in food products was associated, on the average, with a 1.6-percent change in price in the opposite direction; (2) a 1-percent change in the per capita supply of lard was associated, on the average, with a 1.1-percent change in price in the opposite direction; and (3) a 1-percent change in per capita disposable income was associated, on the average, with a 1.4-percent change in price in the same direction.

Table 8 indicates the net effect of each of these factors separately on the price of edible fats and oils, excluding butter and lard. The ratio of each independent variable to its average for the years included in the analysis is shown over a considerable range, together with the related change in price. If the effect of changes in several variables at any one time is desired, this can be obtained by multiplying together the indicated ratio for each item.

For example, suppose that the supply of fats and oils used in food increased by 30 percent above the average supply, the supply of lard increased by 10 percent, and disposable income increased by 50 percent above its average. As indicated in the table, prices of edible fats and oils would increase by 3 percent above the average of the years included in the analysis. This result is obtained as follows: A ratio of supply of fats and oils used in food of 1.30 is associated with a ratio for price of 0.66. A 1.10 ratio for supply of lard is associated with a ratio for price of 0.90. A 1.50 ratio for income is associated with a ratio for price of 1.74. Multiplying the three ratios for price together gives a ratio of 1.03. This is equivalent to an increase of 3 percent in the price of edible fats and oils. For the years included in the analysis, the index of prices of edible fats and oils averaged 50 percent of the 1947-49 average. Thus, the index under the circumstances outlined here would be 1.03 x 50, or 51.5.

Table 9 indicates the actual level of prices in terms of index numbers that would be associated with given levels of the independent variables used in the analysis. Expected prices for levels not indicated directly in this table can be obtained by interpolation. There is a 95-percent chance that estimates obtained from these tables will differ from actual prices, on the average, by not more than 28 percent of the computed price. Illustrations of the use of table 9 are given in Armore (1).

Table 8.- Edible fats and oils, excluding butter and lard: Wholesale price as a ratio to the price expected under specified circumstances in relation to given levels for supply of fats and oils used in food products, supply of lard, and disposable income 1/

Ratio to average for each independent variable	Per capita: Supply of: Fats and oils used in food products 2/	Per capita: Supply of: Lard	Per capita: Disposable income	Ratio of estimated price to price expected with an average-: Supply of: Fats and oils	Ratio of estimated price to price expected with an average-: Supply of: Lard	Ratio of estimated price to price expected with an average-: Income
	Pounds	Pounds	Dollars			
0.50		9.0	326		2.16	0.39
.60		10.8	391		1.76	.50
.70	16.9	12.6	456	1.75	1.49	.61
.80	19.4	14.4	522	1.42	1.28	.74
.90	21.8	16.2	587	1.18	1.12	.87
1.00	24.2	18.0	652	1.00	1.00	1.00
1.10	26.6	19.8	717	.86	.90	1.14
1.20	29.0	21.6	782	.75	.82	1.28
1.30	31.5	23.4	848	.66	.75	1.43
1.40	33.9	25.2	913	.59	.69	1.58
1.50	36.3	27.0	978	.53	.64	1.74
1.60			1,043			1.90
1.70			1,108			2.06
1.80			1,174			2.23
1.90			1,239			2.41
2.00			1,304			2.58
2.10			1,369			2.76
2.20			1,434			2.94
2.30			1,500			3.13
2.40			1,565			3.31

1/ When the other independent variables in the analysis remain at their average level. From an analysis based on logarithms for 1922-42 and 1947-51 presented in Armore (1).

2/ Excluding butter and lard.

Table 9.- Edible fats and oils, excluding butter and lard: Index numbers of wholesale prices with given levels of related factors 1/

(1947-49 = 100)

Supply of fats and oils used in food products per capita 2/	Per capita supply of lard, pounds				
	10	15	20	25	30
Pounds	Disposable income per capita, 500 dollars				
15	129	82	60	46	38
20	82	52	38	30	24
25	58	37	27	21	17
30	43	28	20	16	13
35	34	22	16	12	10
40	28	18	13	10	8
	Disposable income per capita, 1,000 dollars				
15	332	212	154	120	98
20	211	135	98	76	62
25	149	95	69	54	44
30	112	71	52	40	33
35	88	56	41	32	26
40	71	45	33	26	21
	Disposable income per capita, 1,500 dollars				
15	578	369	268	209	171
20	368	235	170	133	109
25	259	165	120	94	77
30	195	124	90	70	57
35	153	97	71	55	45
40	124	79	57	45	37
	Disposable income per capita, 2,000 dollars				
15	857	547	397	310	253
20	545	348	253	197	161
25	384	245	178	139	113
30	289	184	134	104	85
35	226	144	105	82	67
40	184	117	85	66	54

1/ From an analysis based on logarithms for 1922-42 and 1947-51 discussed in Armore (1).
2/ Excluding butter and lard.

Relation of Prices of Soybean Oil to Prices of Fats and Oils, other than Butter and Lard, Used in Food Products

The analysis discussed in the preceding section was concerned with factors that affect the average price of a group of fats and oils, other than butter and lard, used in food products. As this report is concerned primarily with soybean products, an analysis was run to determine the relation of prices of soybean oil to the group average. In view of the considerable influence that the general price level would be expected to have on each of these prices, an index of this variable was included in the analysis. For the reasons indicated in Appendix note 2, the three variables were expressed in terms of logarithms. The analysis was based on the calendar years 1931-42 and 1947-51. This analysis indicated that 79 percent of the variation in prices of soybean oil was associated with changes in prices of all fats and oils, other than butter and lard, used in food products, after allowing for the effects of the general level of wholesale prices. Also it indicated that a 1-percent change in the total index was associated, on the average, with about a 1-percent change in the same direction in the price of soybean oil.

Factors that Affect Prices Received for Soybeans by Farmers

In deciding upon the price they will bid for soybeans, processors are influenced primarily by what they expect will be the value of the products of processing. Their expectations reflect the anticipated yield of oil and meal per bushel of soybeans crushed and the prices at which these products are expected to sell, including sales for both immediate delivery and forward shipment. Forward sales generally are made at prices discounted from spot prices by the amount needed to induce buyers of oil and meal to assume the risk of price changes during the marketing year. The cost of shifting this price risk is taken from the price paid the farmer for his soybeans. 25/ Sabin (18) reported that, during 1947 and 1948, considerable use was made of forward sales by several processing concerns in Illinois for the purpose of shifting price risks.

The difference between the combined value of the oil and meal produced in processing and the price a farmer receives for a bushel of soybeans represents the charges incurred between the farmer and the buyer of the oil and meal. In addition to the risk premium, these charges include those for transportation, processing, handling, financing, and other services. The spread between the value of the final products and the price paid the farmer for soybeans also includes the profit margin, plus or minus the difference between the expected and the realized value of the products.

For the 1931-40 and 1948-50 crop-years, changes in the season-average price of soybeans received by farmers were closely related to changes in the

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25/ For a discussion of processors' buying and selling practices, see Hieronymus and Jordan (6) and Sabin (18).

combined value of the oil and meal obtained per bushel of soybeans processed. 26/ The equation expressing the relationship between the variables used in the analysis indicated that the season-average price of soybeans received by farmers tends to equal 75 percent of the combined value of the soybean products obtained per bushel of soybeans processed, less 12 cents. For example, the average combined value of oil and meal per bushel of soybeans processed for the 1931-40 and 1948-50 crop-years was about $1.71. On the basis of the above relationship, the computed value obtained is equal to the 1931-40 and 1948-50 average price of $1.16 per bushel of soybeans received by farmers. Some of the statistical problems involved in such analyses are discussed in Appendix note 3. The analysis is designed to show normal relationships that have prevailed in the past between certain price and value series; it is not designed to indicate the actual processing margin.

Use of this analysis in measuring the effects of changes in the yield of soybean oil and meal is considered in a later section.

In the September-October 1952 Fats and Oils Situation (21), an analysis was made of the relationship between product value and the season-average price received by farmers for soybeans during the 1951-52 marketing year. The equation just discussed was used to compute the season-average price for soybeans that farmers would have been expected to receive on the basis of a then estimated product value of $3.41. The computed price was $2.44 as compared to an actual price of $2.73. This wide differential can be explained primarily by recent developments in soybean processing and marketing which tended to keep prices of soybeans high relative to product value and which apparently caused a change in the nature of the relationship between the variables. 27/

One development relates to the continuing expansion in the use of the solvent method in soybean processing. As the increased solvent capacity represents new plants and as most screw-press equipment is still operated or is potentially available, total crushing capacity has increased. Apparently, in 1951-52, only about 75 percent of total crushing capacity was utilized. This situation resulted in intensified competition for beans to crush. This competition, and a strong demand for soybean meal, kept prices of soybeans relatively high. An additional development has been the growing tendency on the part of farmers to spread their marketings more evenly over the crop year. This would tend to have an upward effect on the prices received by farmers for soybeans, as they would be paying more of the costs of storage and assuming

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26/ See Appendix note 3.

27/ A difference between the actual and computed season-average price for soybeans this large would be expected to occur by chance less than 2 percent of the time if the assumed relationship were correct and no basic change had taken place in the structure of that relationship. This computation is based on the standard error of forecast for 1951-52 as given in table 12.

more of the price risk in carrying the beans. Whether the spread between product value and the price of soybeans will continue smaller in the future cannot be determined at this time.

Use of These Analyses in Measuring Net Effects of Increased Yields of Soybean Oil on Prices and Total Returns

The way in which changes in the yield of soybean oil and meal would affect various related market factors has been shown. In the case of soybean meal, it is assumed that the changes in supply are too small to affect price significantly. The analyses presented in the preceding section account for the major market factors that would be affected by changes in yields. For convenience of presentation, these analyses are designated as relationships I and II.

Relationship I estimates the effect on wholesale prices of fats and oils, other than butter and lard, used in food products, of changes in the following variables: Per capita supply of fats and oils, excluding butter and lard, used in food products, per capita supply of lard, and personal disposable income per capita. A separate analysis is used to determine the change in the price of soybean oil associated with a change in the price of fats and oils, other than butter and lard, used in food products.

Relationship II estimates the effect of changes in the combined value of soybean oil and meal on the season-average price of soybeans received by farmers.

The statistical analyses discussed in Appendix notes 2 and 3 and in Armore (1) provide the following equations for the two sets of relationships. In each equation the variables that would be directly affected by changes in the yield of soybean oil and meal are underlined.

Relationship I

X_1 - Wholesale price of edible fats and oils, excluding butter and lard, at leading markets, index numbers (1947-49=100).

X_2 - Supply of fats and oils, excluding butter and lard, used in food products, per capita (pounds). The separate items used in computing this variable are shown in Armore (1, table 2).

X_3 - Supply of lard per capita (pounds).

X_4 - Personal disposable income per capita (dollars).

X_1' - Price of soybean oil per pound, crude, tanks, f.o.b. midwestern mills (cents).

X_2' - Bureau of Labor Statistics index of wholesale prices of all commodities (1935-39=100).

The equations expressing the relation between these variables, in terms of logarithms, are as follows:

$$X_1 = 1.37-\underline{1.57X_2}-1.11X_3+1.37X_4$$

$$X_1' = -0.89+\underline{0.96X_1}+0.10X_2'$$

Similar but less precise results could be obtained by using tables 8 or 9 in place of the first equation.

Relationship II

X_1 - Season-average price of soybeans received by farmers, year beginning October (dollars per bushel).

X_2 - Combined wholesale value of the oil and meal obtained per bushel of soybeans processed, year beginning October (dollars).

The equation, expressed in terms of actual data rather than logarithms, is as follows:

$$X_1 = -0.12+\underline{0.75X_2}.$$

These three equations are necessarily based on historical data. Hence, they will be applicable in the future only if there is no basic change in the factors that underlie the individual relationships or, more generally, in the basic structure of the industry. As has been shown, relationship II did not hold in the 1951-52 crop-year primarily because recent developments in the processing and marketing of soybeans tended to keep prices of soybeans high in relation to the combined value of the products obtained per bushel of soybeans processed. It is not known whether these developments will continue similarly to affect prices of soybeans in the future. As indicated in the Preface, the Production and Marketing Administration is studying the types of soybean-processing plants that will be most feasible when new plants are to be built. The equations developed here will be used in their research to ascertain the probable economic effects of the adoption of such plants. However, if the changes indicated appear likely to affect significantly the average cost structure or the competitive nature of the soybean-processing industry, it may be necessary to substitute some sort of accounting relation for relationship II in order to estimate the effects on returns to soybean producers.

In using these equations to estimate probable effects of changes in yields of soybean oil and meal on returns to processors and growers or for other similar purposes, the variables not directly affected by these changes must be held constant at some specified level. The net effects on price and total

returns will depend upon the level selected for these variables. Hence, it is important that such variables be assigned values that are consistent with the use to which the equations are to be put.

All of these equations are based on statistical analyses and are subject to a certain range of statistical error. The magnitudes of the probable errors associated with the last two equations are indicated in Appendix notes 2 and 3. The most important measures of statistical errors associated with the analysis of the factors that affect prices of fats and oils, other than butter and lard, used in food products are listed in footnote 28, p. 38. The complete set of measures of statistical errors relating to this analysis are found in Armore (1).

A detailed example of the use of these equations is given in Appendix note 4.

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APPENDIX

Note 1.- Statistical Methods Used

Techniques of correlation analysis were used to determine and express the relationships discussed in the body of this report. Analyses were run in terms of actual data rather than of first differences. This was because interest centered on the factors that cause the dependent variable to change from its average for the period used in the analysis and not from year to year. Both linear and logarithmic relationships were assumed. Reasons for the choice of the particular type of regression equation are discussed in connection with each analysis. Statistical results from the analyses are presented in notes 2 and 3.

A regression equation is sometimes used to estimate the value of the dependent variable in a given year on the basis of new values for the independent variables. The error involved in a forecast of the dependent variable for any particular year is estimated by a measure known as the standard error of forecast. Under the assumptions leading to the regression analysis, the actual error reflects the fact that only the average of all possible values of the dependent variable is given at a particular point on the regression function. This error is estimated by the standard error of a forecast which allows for the statistical precision of the regression analysis, the extent to which each independent variable differs from its mean in that year, and the average size of the unexplained residuals for the years included in the analysis. Assuming no change in the nature of the relationship, there are 67 chances in 100 that the estimated value plus or minus one standard error of forecast covers the value for the dependent variable, and 95 chances in 100 that the estimated value plus or minus two standard errors of forecast covers the value for the dependent variable.

Note 2.- Soybean Oil: Relation of Price to that for Edible Fats and Oils other than Butter and Lard

The analysis was based on the calendar years 1931-42 and 1947-51, using the following variables:

X_1 Price of soybean oil per pound, crude, tanks, f.o.b. midwestern mills (cents)

X_2 Wholesale price of edible fats and oils, other than butter and lard, leading markets, index numbers (1947-49=100)

X_3 Bureau of Labor Statistics index of wholesale prices of all commodities (1935-39=100)

This analysis was designed to permit application of results from the analysis of the factors that affect prices of edible fats and oils, other than butter and lard, to soybean oil. The latter analysis, discussed on pp. 26-29 of this report and in Armore (1), takes into account the per capita supply of fats and oils used in food products (X_2), per capita supply of lard (X_3), and personal disposable income per capita (X_4) to explain the annual variation in prices of edible fats and oils (X_1). 28/

In the analysis discussed in this note, the variables were expressed in logarithms. This was done primarily because it is believed that the effects of the independent variables on the dependent variable are multiplicative rather than additive and that the relationships are more stable in percentage than in absolute terms. Moreover, use of logarithms facilitates application of results obtained from the analysis of the factors that affect prices of edible fats and oils, which also are given in terms of logarithms.

In order to measure the direct relationship between the price of soybean oil and the composite price of all edible fats and oils, partial regression and correlation coefficients were computed. These measurements indicate the relationship between the first two variables after the effect of the general price level has been eliminated. Simple regression and correlation coefficients also were computed for purposes of comparison. Standard errors of forecast were not obtained. This analysis is designed to measure the relationship between the variables and not to forecast the price of soybean oil from the independent variables.

The original data upon which this analysis is based are given in table 10. Results from the analysis are shown in table 11.

28/ The equation expressing the relation between these variables, in terms of logarithms, and other statistical measures relating to the analysis, are as follows:

$$X_1 = 1.37-1.57X_2-1.11X_3+1.37X_4$$

$s_{b12.34} = 0.27$	$r^2_{12.34} = 0.60$
$s_{b13.24} = .20$	$r^2_{13.24} = .58$
$s_{b14.23} = .09$	$r^2_{14.23} = .91$
$s_{1.234} = .056$	$R^2_{1.234} = .92$

See Armore (1, Appendix note 5).

Table 10.- Wholesale price per pound of soybean oil, and index numbers of wholesale prices of edible fats and oils, excluding butter and lard, and of all commodities, 1931-51

Year	Soybean oil, crude, tanks, f.o.b. mid-western mills	Index numbers of wholesale prices: Edible fats and oils, excluding butter and lard, leading markets (1947-49=100)	Index numbers of wholesale prices: All commodities (1935-39=100) 1/
	Cents		
1931	5.5	28	90.6
1932	3.1	20	80.4
1933	5.4	22	81.8
1934	6.0	30	92.9
1935	8.1	44	99.3
1936	7.5	42	100.2
1937	8.1	43	107.1
1938	5.6	35	97.5
1939	4.8	31	95.7
1940	4.7	30	97.5
1941	8.5	51	108.3
1942	11.6	64	122.6
1943 2/	11.8	64	127.9
1944 2/	11.8	65	129.1
1945 2/	11.8	65	131.3
1946 2/	14.6	80	150.2
1947	23.2	122	188.7
1948	22.3	119	204.8
1949	11.0	58	192.3
1950	14.1	75	200.4
1951	16.8	89	223.8

1/ Bureau of Labor Statistics.

2/ Excluded from the analysis.

Compiled from the Oil, Paint and Drug Reporter (15) and reports of the Bureau of Labor Statistics.

Table 11.- Statistical results from an analysis of the relation between prices of soybean oil, of all edible fats and oils, excluding butter and lard, and of all commodities

Correlation measurement	Variables			
	X_1X_2	X_1X_3	X_2X_3	$X_1X_2X_3$
Partial b	0.96	1/ 0.10		
Standard error of the b	.13	.20		
Partial r^2	.79	1/ .02		
Simple b	1.02			
Simple r^2	.96	.81	0.83	
R^2				0.96
Standard error of estimate				.05
a 2/				-.89

1/ Probability level more than 5 percent; therefore, does not differ significantly from zero. As this relationship is a logical one, however, the variable was retained in the analysis.

2/ Constant value in the regression equation.

Note 3.- Season-Average Price of Soybeans Received by Farmers: Relation to Combined Value of Products of Soybean Processing

The analysis is based on the crop years beginning 1931-40 and 1948-50, using the following variables:

X_1 Season-average price of soybeans received by farmers, year beginning October (dollars per bushel)

X_2 Combined wholesale value of the oil and meal obtained per bushel of soybeans processed, year beginning October (dollars)

The values of the yield of soybean oil and meal were combined into one variable (X_2) because it is believed that a given change in the value of the yield of either would affect the price of soybeans in the same way. Moreover, as a unit change in the combined variable was thought to be associated with a

constant change in the dependent variable over the entire range of observations, a linear relationship between the two variables was assumed. The analysis is based upon the data shown in table 12.

Price data for soybeans shown in table 12 are obtained by weighting season average prices for each State by production. Season average prices for each State are based on monthly prices weighted by estimates of monthly sales during the marketing year. Price data for soybean oil and meal used in the calculation of values of the yield of these products are simple averages of monthly prices for each marketing year. These prices reflect primarily prices of oil and meal sold for immediate delivery. They do not strictly represent actual prices received by processors as they do not take full account of the ordinarily lower prices for sales for deferred delivery. 29/ Furthermore, the meal price series used in the analysis includes the cost of transportation from midwestern mills (where the soybean oil is priced) to Chicago and also the cost of bagging. Data on prices of soybean meal, bulk, Decatur, are available only since 1940. These limitations of the price data for soybean products tend to make the spread between the combined value of these products and the cost of soybeans too wide. Better price series would take into account prices of each product for both immediate and deferred delivery on a bulk basis at the same location and would need to be weighted by sales. Sufficient data for this task are not available.

However, as interest is centered on the average relationship between the combined value of the yield of the soybean products and the prices received by farmers for soybeans, the analysis using simple averages of product prices is believed to give satisfactory results. In a similar investigation on cottonseed and cottonseed products (1, Appendix note 9), use of a series on the total value of products published by the Bureau of the Census (the equivalent of a product-value series based on weighted average product prices) was found to give about the same statistical coefficients as an analysis using a product-value series based on simple averages of product prices. Likewise, an analysis based on prices of soybeans, oil, and meal for October gave almost identical results in terms of the average relationship between the price of the soybeans and the value of the products.

As the bias may be increased disproportionately at high relative price levels, the year 1947 was excluded from the analysis in addition to the years for which price ceilings were in effect.

The following results were obtained:

Statistical coefficients	
b_{12}	0.75

29/ For a comparison of the prices of oil and meal for immediate delivery and the prices actually received by processors for 1947-crop oil and meal sold for both immediate and deferred delivery, by months, see Hieronymus and Jordan (6).

Table 12.- Soybeans: Yield, wholesale price per pound, and value of the oil and meal per bushel of soybeans processed, actual and computed season average price per bushel, 1931-51, and standard errors of forecast, 1941-51

Year beginning October	Soybean oil			Soybean oil meal			Combined value of oil and meal	Soybeans, season average price		
	Yield	Price 1/	Value	Yield 2/	Price 1/	Value 3/		Actual	Computed 4/	Standard error of forecast 5/
	Pounds	Cents	Dollars	Pounds	Cents	Dollars	Dollars	Dollars	Dollars	Dollars
1931	8.5	3.4	0.29	48.5	1.04	0.51	0.80	0.50	0.48	
1932	8.4	4.6	.39	48.6	1.36	.66	1.05	.54	.67	
1933	8.6	5.9	.51	48.4	1.67	.81	1.32	.94	.87	
1934	8.6	7.8	.67	48.4	1.71	.83	1.50	.99	1.01	
1935	8.3	7.4	.61	48.7	1.43	.70	1.31	.73	.86	
1936	8.9	9.1	.81	48.1	2.03	.98	1.79	1.27	1.23	
1937	9.2	5.7	.52	47.8	1.39	.66	1.18	.85	.77	
1938	9.3	4.8	.45	47.7	1.30	.62	1.07	.67	.68	
1939	9.4	4.9	.46	47.6	1.44	.69	1.15	.81	.74	
1940	8.8	7.0	.62	48.2	1.52	.73	1.35	.90	.89	
1941 6/	9.2	11.2	1.03	47.8	2.09	1.00	2.03	1.55	1.41	0.081
1942 6/	9.0	11.8	1.06	48.0	2.14	1.03	2.09	1.61	1.45	.081
1943 6/	8.6	11.8	1.01	48.4	2.60	1.26	2.27	1.81	7/1.59	.082
1944 6/	8.8	11.8	1.04	48.2	2.60	1.25	2.29	2.05	7/1.60	.082
1945 6/	8.9	11.9	1.06	48.1	3.12	1.50	2.56	2.08	7/1.80	.084
1946 6/	9.0	22.8	2.05	48.0	4.06	1.95	4.00	2.57	2.39	.099
1947 6/	9.5	23.7	2.25	47.5	4.58	2.18	4.43	3.34	3.21	.106
1948	9.8	13.1	1.28	47.2	3.82	1.80	3.08	2.27	2.19	.088
1949	9.9	12.3	1.22	48.0	3.73	1.79	3.01	2.16	2.14	.087
1950	9.7	17.8	1.73	47.6	3.85	1.83	3.56	2.47	2.55	.093
1951 6/	10.0	11.3	1.13	47.6	8/4.81	2.29	3.42	2.73	2.45	.091

1/ Simple average price per pound, year beginning October, using the following quotations: Soybean oil, crude, tank cars, f.o.b. midwestern mills; soybean meal, bagged, Chicago, quoted as 41-percent protein beginning November 1936, 44-percent protein beginning July 1950.

2/ 1931-48 yields computed by taking 95 percent of total weight (60 pounds) of a bushel of soybeans minus corresponding yield of oil; thereafter computed from data reported by the Bureau of the Census.

3/ Based on unrounded price data.

4/ From the regression equation: $X_1 = -0.12 + 0.75X_2$.

5/ For formula, see Foote (4, p. 4).

6/ Not used in the analysis.

7/ In order to stimulate production, support prices for soybeans during the 1943-45 seasons were set above the price processors could pay on the basis of ceiling prices for oil and meal. The Commodity Credit Corporation bought soybeans from processors at the support price and resold the soybeans to them at a lower price based on their oil content. The analysis indicates the prices for soybeans that would have been expected on the basis of the 1943-45 ceiling prices for the products.

8/ April-September prices used in the computation were for soybean meal mix as most soybean meal in these months was sold in this form.

Compiled from reports of the Bureau of the Census, Production and Marketing Administration, and the Oil, Paint and Drug Reporter (15).

Standard error of b_{12}	.025
r^2_{12}	.99
Standard error of estimate	.078
a	-.12

Table 12 also shows the actual and computed season-average price of soybeans received by farmers for the years used in the analysis and those excluded and standard errors of forecast for 1941-51.

The analysis also was run with the variables expressed in terms of first differences (actual changes from the preceding year). Using this approach, the slope of the regression line (b_{12}) was 0.79 and the proportion of the variation in X_1 explained by X_2 (r^2_{12}) was 93 percent. These results are nearly the same as those obtained from the analysis based on actual data.

Note 4.- Steps Involved in Computing Net Effects of Increased Yields of Soybean Oil on Prices and Total Returns from Soybeans

The following example is given to show the exact steps involved in the use of the three equations in relation to a specific problem. For illustrative purposes, a 10-percent increase in the yield of soybean oil per bushel of soybeans crushed above the 1948-50 average level is assumed. The variables not directly affected by this change in yield are held constant at their average level for the 1948-50 crop-years or the 1949-51 calendar years, depending upon the particular series involved. Background data for this period are presented in the following tabulation.

Selected market factors used in connection with relationships I and II: Average, crop years beginning 1948-50 or calendar years 1949-51

Item	Unit	Average
Soybean oil:		
Yield per bushel of soybeans crushed 1/	Pound	9.8
Stocks, January 1 2/	Million pound	164
Soybean oil meal:		
Yield per bushel of soybeans crushed 1/	Pound	47.6
Wholesale price per pound 1/ 3/	Cent	3.8
Soybeans:		
Quantity sold for all purposes 1/ 4/	Million bushel	239.6
Quantity crushed 1/	do.	210.0

-- continued

Selected market factors used in connection with relationships I and II: Average, crop years beginning 1948-50 or calendar years 1949-51 -- Continued

Item	Unit	Average
Supply per person 5/:		
Lard	Pound	18.7
Other fats and oils used in food products, excluding butter:		
Soybean oil	do.	15.1
Other than soybean oil	do.	15.1
Total	do.	30.2
Disposable income per person 5/	Dollar	1,339
Index of wholesale prices of all commodities (1935-39 = 100) 5/		205.5
Population, United States, July 1 5/ 6/	Million	152.6

1/ Year beginning October.
2/ Crude plus refined as reported.
3/ Bagged, Chicago, quoted as 41-percent protein before July 1950; 44-percent protein thereafter.
4/ Includes soybeans sold for processing, export, food, and for use on farms other than where produced.
5/ Calendar year.
6/ Includes armed forces overseas and is adjusted for underenumeration of children under 5 years of age.

Steps used are as follows:

1. Yield of soybean oil per bushel of soybeans crushed--1948-50 average (9.8 pounds) from the above tabulation times 1.10 equals 10.8 pounds.

2. Production of soybean oil--1948-50 average quantity of soybeans crushed for oil (210 million bushels) times yield of soybean oil per bushel of soybeans crushed of 10.8 pounds equals 2,268 million pounds.

3. Supply of soybean oil per capita--Production (2,268 million pounds) plus 1949-51 average stocks on January 1 (164 million pounds) divided by 1949-51 average total population on July 1 (152.6 million) equals 15.9 pounds.

4. Supply of fats and oils used in food products per capita--Supply of soybean oil per capita of 15.9 pounds plus 1949-51 average per capita supply of other items (15.1 pounds) equals 31.0 pounds.

5. Wholesale price of fats and oils, excluding butter and lard, used in food products--Computations based on the analysis discussed on pp. 26-29 are shown below:

a. The 1949-51 average supply of lard of 18.7 pounds per capita converted to logarithms (1.2718) and multiplied by the partial regression coefficient

for lard of -1.110 gives -1.4117.

b. The 1949-51 average disposable income of 1,339 dollars per capita converted to logarithms (3.1268) and multiplied by the partial regression coefficient for income of 1.369 gives 4.2806.

c. The results of steps a and b combined with the constant value from the regression equation of 1.3736 gives 4.2425.

d. The assumed supply of edible fats and oils per capita from step 4 of 31.0 pounds converted to logarithms (1.4914) and multiplied by the partial regression coefficient for this supply of -1.571 gives -2.3430. Adding this algebraically to the result from step c gives 1.8995. The antilogarithm of this is 79. This result represents the index number of wholesale prices of fats and oils, other than butter and lard, used in food products on a 1947-49 base which normally would be associated with a supply of fats and oils and a disposable income of the indicated magnitudes.

6. Wholesale price of soybean oil--Computations based on the analysis discussed in Appendix note 2 are shown below:

a. The 1949-51 average index of wholesale prices of all commodities of 205.5 converted to logarithms (2.3128) and multiplied by the partial regression coefficient for this index of 0.1042 gives 0.2410.

b. The result from step a combined algebraically with the constant value from the regression equation of -0.8906 gives the relevant constant for this step of -0.6496.

c. The final logarithm (1.8995) from step 5 multiplied by the partial regression coefficient of 0.9599 gives 1.8233. Adding algebraically the constant value of step b gives 1.1737. The antilogarithm of this is 14.9 cents.

7. Value of yield of soybean oil per bushel of soybeans crushed--Yield from step 1 (10.8 pounds) times price from step 6 (14.9 cents) equals $1.61.

8. Yield of soybean oil meal per bushel of soybeans crushed--1948-50 average (47.6 pounds) minus increase in yield of soybean oil (1 pound) equals 46.6 pounds.

9. Value of yield of soybean meal per bushel of soybeans crushed--Yield from step 8 (46.6 pounds) times price from above tabulation of 3.8 cents equals $1.77.

10. Value of oil and meal per bushel of soybeans processed--Value of soybean oil of $1.61 plus value of soybean meal of $1.77 equals $3.38.

11. Season-average price of soybeans--Computations based on the analysis discussed in Appendix note 3 are shown on the next page:

The value from step 10 of $3.38 is multiplied by the regression coefficient 0.7512 and added algebraically to the constant value from the regression equation of -0.1196 to give $2.42. This result represents the season-average price for soybeans that farmers would have been expected to receive assuming that margins of soybean processors are the same as those normally associated with combined values of products at the indicated levels (see pages 31-32).

12. Cash receipts of farmers for soybeans--1948-50 average quantity of soybeans sold (239.6 million bushels) times the season-average price received by farmers per bushel from step 11 ($2.42) equals 580 million dollars. As in step 11, this result represents the receipts that farmers would get assuming that margins of soybean processors are the same as those normally associated with combined values of products at the levels indicated. If these margins were expected to change, an alternative computing procedure for step 11 would be required, and the result in step 12 possibly would be changed.

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